

Hydrologic budgets of the ORW mitigation wetland, 2001

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Introduction

Understanding the hydrologic processes of mitigation wetlands is a fundamental key in effective ecosystem restoration and creation (Mitsch and Gosselink, 2000). One indicator of success for constructed wetlands is the fulfillment of the hydrology criterion (National Research Council, 1995). Hydrologic budgets, therefore, provide valuable information to meet restoration and creation goals.

The 3-ha mitigation wetland (the billabong) at the Olentangy River Wetland Research Park, constructed in the summer of 1996, is a freshwater, oxbow wetland that receives water from the Olentangy River. When the river level is higher than the wetland, water passively flows into the wetland through a check valve and eventually returns to the Olentangy River through a control weir. Previous hydrologic budgets from the beginning were presented in Wang et al. (1997), Johnson et al. (1998), Zhang and Mitsch (2000, 2001). This paper presents monitoring hydrologic budgets for 2001.

Methods

Location of the inflow and outflow of the billabong is shown in Figure 1. A twice-daily reading (staff gauges) was used to measure the surface water level of the Olentangy River and mitigation wetland. The following equation (Mitsch and Gosselink, 2000) was used to determine hydrologic budgets for the mitigation wetland:

$$\Delta V/\Delta t = Q_{in} + Q_{out} + G_{in/out} + P_{reci} - ET \quad \text{Eqn. 1}$$

where

$\Delta V/\Delta t$ = Change of water volume in wetland over time,

Q_{in} = Inflow,

Q_{out} = Surface outflow,

$G_{in/out}$ = Ground water exchange,

P_{reci} = Precipitation,

ET = Evapotranspiration.

All parameters (water inflows, outflows, water volume, precipitation and evapotranspiration, and groundwater) in equation (1) were calculated by the following equations (Wang et al., 1997):

Inflow

$$S_i = 1.8447ah^{1/2} \quad \text{Eqn. 2}$$

$$a = 0.7372D + 1.387D^2 - 0.39993D^3 \quad \text{Eqn. 3}$$

= cross sectional area, ft

$$L_r = 723 + L_s \quad \text{Eqn. 4}$$

where

D = water depth in pipe at weir box (ft)

= min (d, max (0, $L_r - 723.5$))

h = head causing flow (ft)

= max (0, min ($L_r - L_m$, $L_r - 0.6D - 723.5$))

L_r = river water level (ft above MSL)

L_s = staff gauge reading, ft

L_m = mitigation wetland water level (ft above MSL)

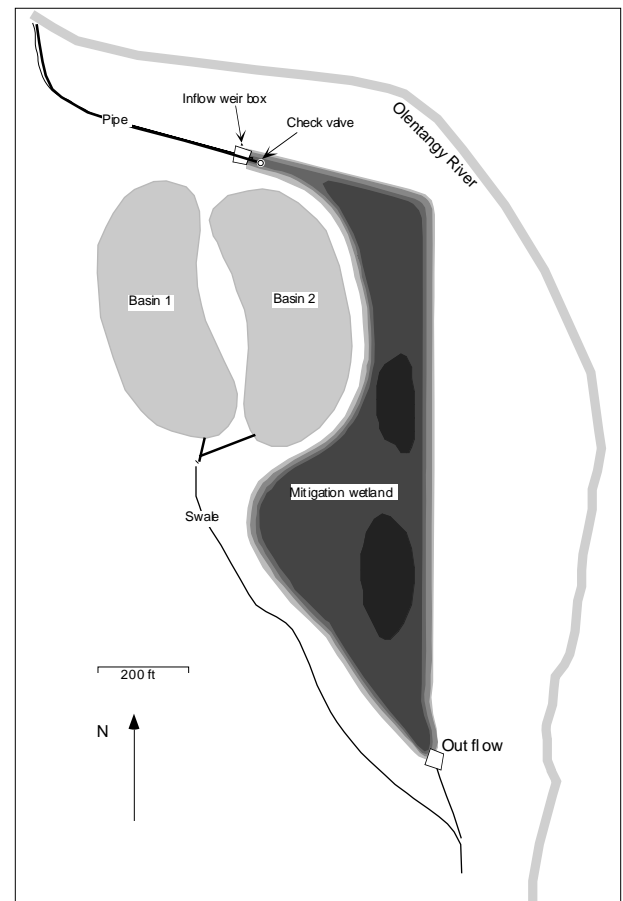


Figure 1. Location of the mitigation wetland at ORWRP.

Outflow

$$S_0 = 10.16 h_0^{1.436} \quad \text{Eqn 5}$$

where

$$h_0 = \begin{cases} L_m - 724.2 & (L_m > 724.2) \\ 0 & (L_m < 724.2) \end{cases}$$

Surface water volume

Surface water volume was based on relationships between surface area, volume, and elevation. A detailed modeling approach was given by Wang et al. (1997). The following equation was used to calculate water volume (V , ft^3) of the mitigation wetland:

$$V = \begin{cases} 3.5873 \times 10^4 L_m - 2.5938 \times 10^7 & (0 < L_m < 723.5) \\ 6.8425 \times 10^9 - 1.9121 \times 10^7 L_m + 1.336 \times 10^4 L_m^2 & (723.5 < L_m < 727.0) \end{cases} \quad \text{Eqn 6}$$

Daily precipitation and ET

Daily precipitation and evapotranspiration data were extracted from Ohio State University and the weather station (Mitsch et al., 1995) at ORWRP. Evapotranspiration data was used from the year 1999, because of absent data from both weather stations in 2001.

Groundwater exchange

The difficulties of evaluating groundwater seepage for the mitigation wetland were presented in Wang et al. (1997). The residuals, however, were used to estimate groundwater indirectly after balancing all other components of the hydrologic budgets (eqn. 1).

Results and Discussion

Figure 2 shows the hydroperiod of the wetland and the Olentangy River for 2001. General water level trends of the billabong follow a pattern of high water levels in the early growing season, followed by drier conditions in late summer. This early flooding followed by summer drawdowns is typical of midwest marshes (Mitsch, 1992). These flood events provide nutrients and introduction of seeds and small organisms across a watershed (Mitsch and Gosselink, 2000).

Figure 3 presents the relationships between surface water level (ft above MSL) and wet area (%) of the total mitigation wetland area, and wet periods (days) during two growing seasons (a: from April 20 to Oct. 20; and b: from May 1 to Oct. 31 during the period 2001). A summary of the wet days and wet area for the two growing seasons is given in Table 1. The wet periods are considerably longer than the hydrologic critical days which were given by National Research Council (1995) for wetland delineations and indicate that the design of this wetland was successful in establishing appropriate hydrologic conditions for a Midwest oxbow wetland.

Table 2 shows the annual hydrologic budgets for 2001. Daily values are given in Appendix A. By comparison, total inflow 6.8 m/yr from the river in 2001 was lower than the inflow 11.10 m/yr in 2000 and 9.25 m/yr in 1999 (Zhang and Mitsch, 2000, 2001). Total precipitation (1.3 m/yr) and evapotranspiration (2.2 m/yr) in 2001 were also more than total precipitation (0.91 m/yr) and evapotranspiration (0.91 m/yr) in 2000 (Zhang and Mitsch, 2001).

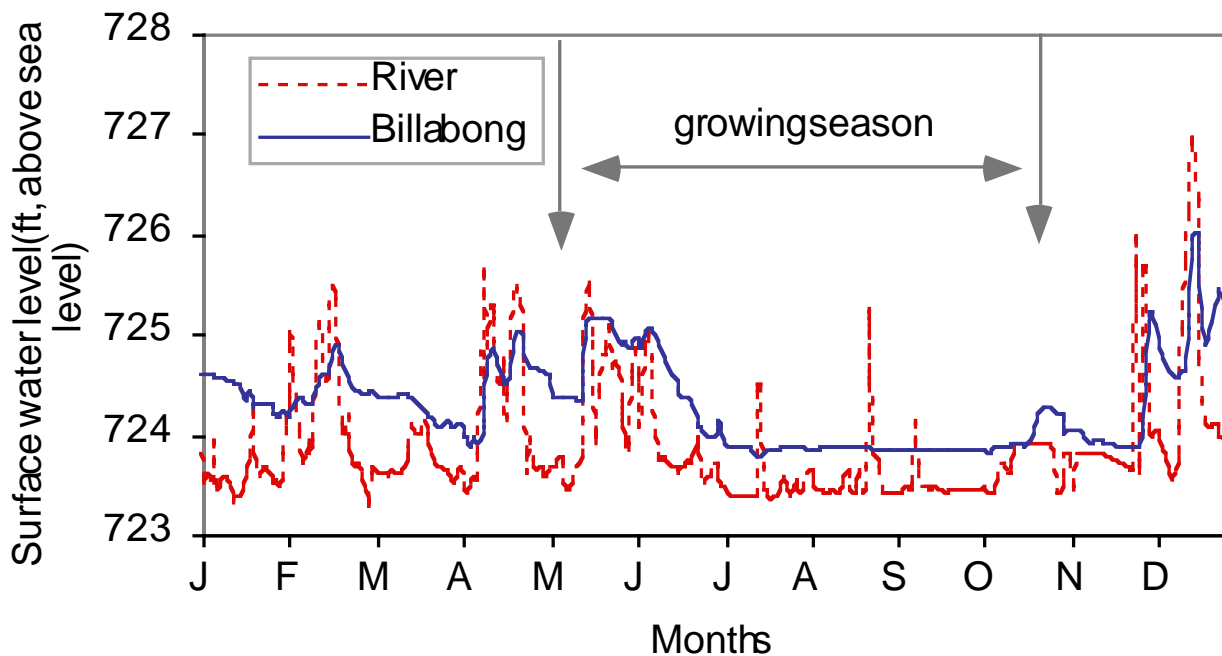


Figure 2. Daily surface water level (ft above sea level) in 2001.

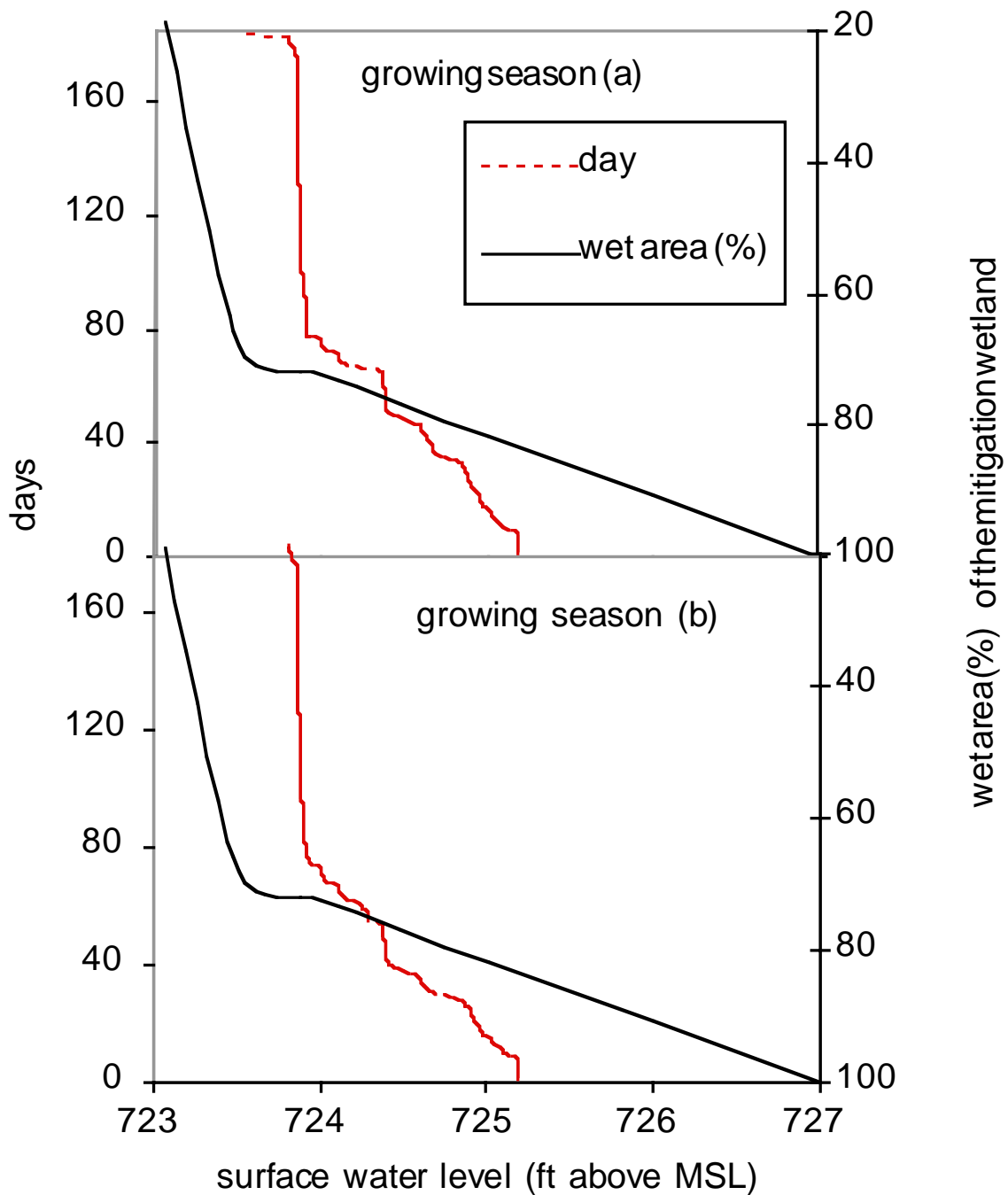


Figure 3. Relationship of surface water level to wet days and wet area (%) of the billabong during different definitions of the growing seasons (a: Apr 20 - Oct 19; b: May 1 - Oct 31), 2001.

Table 1. A summary of the wet days and wet area for the two growing seasons in 2001.

wet area%	68	72	82
growing seasons	wet days		
April 20 - October 19 2000	184	76	17
May 1 - October 31 2000	184	73	15

Table 2. Estimated annual hydrologic budgets, 2001.

hydrologic parameters	2001 (m/yr)
Surface inflow from river	6.8
Surface outflow	6.3
Precipitation	1.4
Evapotranspiration	2.2

References

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Appendix A. Estimated daily hydrologic budgets for the billabong at ORWRP, 2001.

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
01/01/01	724.41	724.60	234311	0	0	0	0
01/02/01	723.51	724.20	234311	0	0	0	0
01/03/01	723.61	724.61	236325	0	0	0	0
01/04/01	723.61	724.60	234603	0	0	42895	508
01/05/01	723.52	724.60	233815	0	0	5316	584
01/06/01	723.94	724.59	232170	0	0	701	1166
01/07/01	723.47	724.58	230343	0	0	701	1502
01/08/01	723.51	724.58	229601	0	0	701	1773
01/09/01	723.60	724.58	229601	0	0	3338	5482
01/10/01	723.58	724.56	223815	0	0	701	3895
01/11/01	723.49	724.55	222062	0	0	2019	455
01/12/01	723.34	724.52	215847	0	0	701	2265
01/13/01	723.41	724.50	211533	0	0	701	2661
01/14/01	723.39	724.50	210869	0	0	22457	5617
01/15/01	723.39	724.50	210379	0	0	15205	5349
01/16/01	723.47	724.42	192421	0	0	701	5530
01/17/01	723.61	724.34	173918	0	0	701	1821
01/18/01	723.80	724.45	199880	0	0	27732	2265
01/19/01	724.28	724.30	164554	0	0	15205	6023
01/20/01	723.90	724.27	157356	0	0	1360	5646
01/21/01	723.77	724.30	164787	0	0	701	3471
01/22/01	723.60	724.30	164787	0	0	1360	5045
01/23/01	723.65	724.30	164787	0	0	25754	5312
01/24/01	723.68	724.30	164787	0	0	701	903
01/25/01	723.63	724.30	164787	0	0	701	1837
01/26/01	723.58	724.30	164787	0	0	701	283
01/27/01	723.53	724.22	147700	0	0	701	2187
01/28/01	723.54	724.22	146398	0	0	701	1830
01/29/01	723.51	724.20	141338	0	0	701	470
01/30/01	723.55	724.26	156656	0	0	701	3900
01/31/01	724.12	724.21	144610	0	0	701	6435

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
02/01/01	724.38	724.18	137438	54812	0	701	4147
02/02/01	725.04	724.24	151822	192958	4807	701	1465
02/03/01	724.89	724.30	164098	161515	15518	13887	10143
02/04/01	724.31	724.34	173122	0	0	7294	6372
02/05/01	724.06	724.39	186455	0	0	701	1263
02/06/01	723.73	724.37	180879	0	0	2019	2385
02/07/01	723.83	724.30	164787	0	0	701	11197
02/08/01	723.95	724.30	164787	0	0	2019	15110
02/09/01	723.82	724.30	164787	0	0	62015	11948
02/10/01	723.88	724.30	164787	0	0	701	13284
02/11/01	724.67	724.44	197627	83410	58038	701	9616
02/12/01	725.15	724.51	214074	210994	83763	701	1800
02/13/01	725.00	724.60	235330	150001	120571	701	2267
02/14/01	724.54	724.61	236480	0	0	9931	8118
02/15/01	724.65	724.61	235682	35020	121209	701	13470
02/16/01	725.08	724.69	255076	157619	157796	701	13102
02/17/01	725.49	724.79	278708	263134	205616	701	2454
02/18/01	725.44	724.92	311820	222902	277706	4657	1678
02/19/01	724.57	724.90	305637	0	0	3997	908
02/20/01	724.02	724.78	276383	0	0	701	2130
02/21/01	724.02	724.65	246608	0	0	701	3815
02/22/01	724.21	724.58	230447	0	0	701	5936
02/23/01	723.94	724.55	222733	0	0	701	10489
02/24/01	723.79	724.49	207996	0	0	701	2275
02/25/01	723.69	724.45	200237	0	0	701	4726
02/26/01	723.72	724.44	197933	0	0	2019	15012
02/27/01	723.61	724.41	189424	0	0	12568	10947
02/28/01	723.46	724.40	188509	0	0	701	12410
03/01/01	723.32	724.42	191272	0	0	36962	8949
03/02/01	723.31	724.42	193150	0	0	5316	8100
03/03/01	723.70	724.44	195797	0	0	701	8387
03/04/01	723.67	724.41	190752	0	0	5975	3541
03/05/01	723.64	724.40	187022	0	0	14546	4161
03/06/01	723.61	724.38	183778	0	0	701	7217
03/07/01	723.63	724.39	184476	0	0	701	10202
03/08/01	723.62	724.37	181780	0	0	44214	9464
03/09/01	723.61	724.37	181890	0	0	701	2626
03/10/01	723.64	724.37	180904	0	0	701	2840
03/11/01	723.61	724.37	180832	0	0	11249	7957
03/12/01	723.61	724.38	184183	0	0	701	9950
03/13/01	723.62	724.42	192308	0	0	701	9020
03/14/01	723.68	724.42	192308	0	0	701	9891
03/15/01	723.80	724.42	192152	0	0	701	11859
03/16/01	723.82	724.38	184173	0	0	701	11860
03/17/01	724.11	724.38	183435	0	0	701	12039
03/18/01	724.03	724.35	176506	0	0	701	2516
03/19/01	724.01	724.32	168794	0	0	701	3920
03/20/01	724.04	724.29	163334	0	0	701	7262
03/21/01	724.16	724.26	155121	0	0	701	2415
03/22/01	724.02	724.21	145100	0	0	701	3025
03/23/01	723.93	724.19	139189	0	0	701	7672
03/24/01	723.81	724.18	137651	0	0	701	10124
03/25/01	723.75	724.15	131158	0	0	701	12375
03/26/01	723.69	724.10	119773	0	0	701	7947
03/27/01	723.69	724.10	119773	0	0	701	16651
03/28/01	723.67	724.13	126705	0	0	701	14588
03/29/01	723.64	724.17	134879	0	0	701	9065
03/30/01	723.61	724.16	133156	0	0	701	9949
03/31/01	723.60	724.12	124437	0	0	701	10834

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Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
04/01/01	723.52	724.09	117949	0	0	701	11719
04/02/01	723.64	724.11	120978	0	0	701	2519
04/03/01	723.69	724.11	122251	0	0	5316	3157
04/04/01	723.53	724.08	116234	0	0	701	2350
04/05/01	723.51	724.00	97117	0	0	7953	2355
04/06/01	723.43	724.00	97117	0	0	2019	4907
04/07/01	723.54	723.89	74604	0	0	701	4451
04/08/01	723.58	723.97	91489	0	0	701	2502
04/09/01	723.57	723.92	80182	0	0	701	3079
04/10/01	724.82	723.95	87608	148742	0	5316	1810
04/11/01	724.59	724.09	118346	105254	0	29709	4850
04/12/01	725.66	724.29	162039	309862	13481	701	5019
04/13/01	724.87	724.70	258697	86311	164905	701	4866
04/14/01	725.32	724.81	283361	208537	215408	1360	3726
04/15/01	725.29	724.86	296677	187010	244059	701	1683
04/16/01	724.58	724.78	276526	0	0	701	2238
04/17/01	724.51	724.65	246424	0	0	17842	2802
04/18/01	724.78	724.58	230279	86366	111496	4657	4003
04/19/01	724.49	724.53	218638	0	0	2679	2722
04/20/01	724.15	724.50	211031	0	0	13887	1052
04/21/01	724.77	724.59	232354	80742	115200	2679	4108
04/22/01	725.37	724.85	292896	215528	235831	701	2871
04/23/01	725.50	725.02	336591	218877	334968	58059	3013
04/24/01	725.37	725.05	343105	169394	350451	701	4258
04/25/01	725.02	724.97	323157	52594	303586	46851	4205
04/26/01	724.69	724.88	300662	0	0	701	3038
04/27/01	723.67	724.73	265704	0	0	701	1430
04/28/01	723.99	724.69	254515	0	0	701	4984
04/29/01	723.76	724.68	252657	0	0	2019	4738
04/30/01	723.65	724.67	250227	0	0	701	4146
05/01/01	723.69	724.66	247720	0	0	701	3553
05/02/01	723.69	724.64	244783	0	0	0	809
05/03/01	723.64	724.63	241373	0	0	0	4043
05/04/01	723.58	724.62	238028	0	0	0	3234
05/05/01	723.69	724.60	235460	0	0	0	809
05/06/01	723.68	724.39	185751	0	0	0	0
05/07/01	723.68	724.38	183852	0	0	4717	0
05/08/01	723.78	724.37	180567	0	0	0	1617
05/09/01	723.76	724.40	186571	0	0	4717	809
05/10/01	723.56	724.40	187135	0	0	0	1617
05/11/01	723.49	724.39	185223	0	0	674	0
05/12/01	723.46	724.38	183343	0	0	0	1617
05/13/01	723.53	724.38	184237	0	0	0	4043
05/14/01	723.69	724.37	181597	0	0	0	38005
05/15/01	723.71	724.36	179142	0	0	0	0
05/16/01	723.91	724.39	184953	0	0	33692	0
05/17/01	724.96	724.53	217619	151405	89641	0	3234
05/18/01	725.23	725.09	353392	104788	375233	0	8895
05/19/01	725.54	725.18	375547	192119	429928	0	0
05/20/01	724.95	725.18	375547	0	0	0	0
05/21/01	723.92	725.18	375546	0	0	4043	0
05/22/01	724.62	725.18	375545	0	0	0	809
05/23/01	724.83	725.18	375544	0	0	0	0
05/24/01	724.79	725.18	375544	0	0	0	61454
05/25/01	724.81	725.18	375543	0	0	0	0
05/26/01	725.10	725.18	375542	0	0	0	1617
05/27/01	724.66	725.13	362445	0	0	0	6469
05/28/01	724.74	725.02	334854	0	0	0	1617
05/29/01	724.68	724.94	315491	0	0	0	7278

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
05/30/01	724.34	724.91	308140	0	0	0	1617
05/31/01	724.22	724.92	310723	0	0	0	3234
06/01/01	723.97	724.96	320093	0	0	0	13746
06/02/01	723.87	724.87	297729	0	0	1348	0
06/03/01	724.64	724.86	296652	0	0	4043	1617
06/04/01	724.88	724.97	322328	0	0	0	0
06/05/01	724.52	724.95	319188	0	0	0	4852
06/06/01	724.09	724.89	303129	0	0	0	3234
06/07/01	724.21	724.89	303849	0	0	0	4043
06/08/01	724.86	725.03	338709	0	0	0	3234
06/09/01	725.07	725.08	351452	0	0	0	6469
06/10/01	724.66	725.07	347559	0	0	0	4852
06/11/01	723.97	725.02	336421	0	0	0	5660
06/12/01	723.82	724.95	318261	0	0	0	5660
06/13/01	723.79	724.90	305626	0	0	0	5660
06/14/01	723.77	724.83	289201	0	0	0	8086
06/15/01	723.78	724.77	274619	0	0	29649	0
06/16/01	723.74	724.68	253191	0	0	0	809
06/17/01	723.69	724.60	234091	0	0	0	2426
06/18/01	723.68	724.57	227871	0	0	674	809
06/19/01	723.69	724.49	208365	0	0	0	3234
06/20/01	723.64	724.44	195974	0	0	0	3234
06/21/01	723.69	724.37	181649	0	0	0	6469
06/22/01	723.69	724.38	182247	0	0	0	12129
06/23/01	723.77	724.38	183092	0	0	0	16981
06/24/01	723.74	724.36	178500	0	0	0	0
06/25/01	723.86	724.24	151066	0	0	0	0
06/26/01	723.99	724.12	124123	0	0	0	809
06/27/01	723.94	724.10	119773	0	0	0	1617
06/28/01	723.66	724.10	119678	0	0	0	1617
06/29/01	723.51	724.01	100102	0	0	0	0
06/30/01	723.60	724.00	97667	0	0	02	0
07/01/01	723.58	724.00	97667	0	0	0	1617
07/02/01	723.71	724.00	97667	0	0	0	13353
07/03/01	723.72	724.04	105997	0	0	0	18101
07/04/01	723.63	724.16	133035	0	0	0	18160
07/05/01	723.54	724.11	121999	0	0	0	17229
07/06/01	723.50	723.92	81045	0	0	0	27722
07/07/01	723.42	723.90	75828	0	0	0	15351
07/08/01	723.40	723.90	75828	0	0	499	10526
07/09/01	723.38	723.90	75828	0	0	499	21472
07/10/01	723.40	723.90	75828	0	0	499	23882
07/11/01	723.40	723.90	75779	0	0	40539	20487
07/12/01	723.41	723.88	72195	0	0	499	19836
07/13/01	723.40	723.88	71492	0	0	499	19389
07/14/01	723.40	723.88	71492	0	0	499	16688
07/15/01	723.41	723.87	70093	0	0	499	7229
07/16/01	723.41	723.84	62418	0	0	499	19703
07/17/01	723.41	723.80	55209	0	0	499	37340
07/18/01	724.44	723.80	54256	80975	0	499	33795
07/19/01	724.50	723.80	54256	90533	0	499	26875
07/20/01	723.45	723.82	59624	0	0	499	26109
07/21/01	723.45	723.86	67167	0	0	9397	19418
07/22/01	723.38	723.86	67167	0	0	29735	17661
07/23/01	723.40	723.86	67167	0	0	29735	18559
07/24/01	723.40	723.86	67167	0	0	499	13146
07/25/01	723.40	723.86	67167	0	0	499	23169
07/26/01	723.47	723.87	68439	0	0	499	15560
07/27/01	723.59	723.88	71492	0	0	499	14148

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
07/28/01	723.52	723.89	72605	0	0	499	15928
07/29/01	723.41	723.89	72605	0	0	499	14678
07/30/01	723.50	723.89	72813	0	0	499	14345
07/31/01	723.56	723.89	72839	0	0	499	14012
08/01/01	723.49	723.89	72683	0	0	499	13679
08/02/01	723.43	723.88	71838	0	0	499	9505
08/03/01	723.45	723.87	70284	0	0	499	8482
08/04/01	723.63	723.87	68768	0	0	499	6351
08/05/01	723.66	723.86	67708	0	0	499	4168
08/06/01	723.66	723.86	67102	0	0	499	4428
08/07/01	723.57	723.86	66951	0	0	499	11065
08/08/01	723.47	723.86	67553	0	0	499	10625
08/09/01	723.47	723.87	68784	0	0	499	6703
08/10/01	723.45	723.87	69991	0	0	499	6640
08/11/01	723.42	723.88	70845	0	0	499	11849
08/12/01	723.43	723.88	71345	0	0	499	11212
08/13/01	723.43	723.88	71492	0	0	499	17549
08/14/01	723.45	723.88	71492	0	0	499	12066
08/15/01	723.45	723.88	71492	0	0	1770	16095
08/16/01	723.44	723.88	71492	0	0	499	9074
08/17/01	723.42	723.88	71492	0	0	499	14087
08/18/01	723.51	723.88	71492	0	0	499	21065
08/19/01	723.62	723.88	71492	0	0	499	30991
08/20/01	723.67	723.88	71492	0	0	499	20562
08/21/01	723.49	723.88	71492	0	0	499	18039
08/22/01	723.44	723.88	71492	0	0	499	15198
08/23/01	723.44	723.88	71492	0	0	499	7281
08/24/01	723.66	723.88	71492	0	0	499	6544
08/25/01	723.44	723.88	71444	0	0	499	5935
08/26/01	723.45	723.88	71165	0	0	499	6067
08/27/01	724.64	723.88	70655	114209	0	499	8069
08/28/01	725.22	723.87	69934	230037	0	499	8253
08/29/01	723.84	723.87	69213	0	0	499	7451
08/30/01	723.79	723.87	68493	0	0	499	7358
08/31/01	723.74	723.86	67820	0	0	499	7264
09/01/01	723.43	723.86	67379	0	0	499	7171
09/02/01	723.43	723.86	67167	0	0	0	3234
09/03/01	723.43	723.86	67167	0	0	0	10512
09/04/01	723.43	723.86	67167	0	0	0	1617
09/05/01	723.43	723.86	67167	0	0	0	3234
09/06/01	723.43	723.86	67167	0	0	0	8895
09/07/01	723.43	723.86	67167	0	0	46495	20215
09/08/01	723.43	723.86	67167	0	0	0	809
09/09/01	723.49	723.86	67167	0	0	0	0
09/10/01	723.49	723.86	67167	0	0	0	1617
09/11/01	723.49	723.86	67167	0	0	0	0
09/12/01	723.47	723.86	67167	0	0	0	35579
09/13/01	724.14	723.86	67167	38675	0	0	0
09/14/01	723.66	723.86	67167	0	0	0	0
09/15/01	723.49	723.86	67167	0	0	0	12129
09/16/01	723.49	723.86	67167	0	0	0	5660
09/17/01	723.47	723.86	67167	0	0	0	5660
09/18/01	723.46	723.86	67167	0	0	0	2426
09/19/01	723.47	723.86	67167	0	0	0	5660
09/20/01	723.50	723.86	67167	0	0	6065	25876
09/21/01	723.47	723.86	67167	0	0	1348	4852
09/22/01	723.44	723.86	67167	0	0	0	4043
09/23/01	723.42	723.86	67167	0	0	0	26684
09/24/01	723.44	723.86	67167	0	0	0	2426

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
09/25/01	723.45	723.86	67167	0	0	0	1617
09/26/01	723.46	723.86	67167	0	0	0	5660
09/27/01	723.46	723.86	67167	0	0	2695	809
09/28/01	723.46	723.86	67167	0	0	0	7278
09/29/01	723.46	723.86	67167	0	0	50538	0
09/30/01	723.46	723.86	67167	0	0	2695	0
10/01/01	723.46	723.86	67167	0	0	0	0
10/02/01	723.46	723.86	67167	0	0	0	1617
10/03/01	723.46	723.86	67167	0	0	0	809
10/04/01	723.46	723.86	67167	0	0	3369	0
10/05/01	723.46	723.86	67167	0	0	2695	809
10/06/01	723.47	723.86	67167	0	0	0	0
10/07/01	723.51	723.86	67167	0	0	0	1617
10/08/01	723.50	723.86	67167	0	0	0	50134
10/09/01	723.43	723.83	60590	0	0	8086	57411
10/10/01	723.42	723.83	60745	0	0	20889	0
10/11/01	723.42	723.90	74834	0	0	5391	6469
10/12/01	723.58	723.90	75828	0	0	0	35579
10/13/01	723.73	723.90	75828	0	0	0	1617
10/14/01	723.73	723.90	75828	0	0	24258	0
10/15/01	723.73	723.90	75828	0	0	0	52560
10/16/01	723.63	723.90	75828	0	0	0	5660
10/17/01	723.63	723.90	76503	0	0	0	2426
10/18/01	723.89	723.91	77908	0	0	8086	809
10/19/01	723.92	723.91	78000	4916	0	674	0
10/20/01	723.92	723.91	78000	4959	0	0	1617
10/21/01	723.92	723.91	77701	4872	0	0	28301
10/22/01	723.92	723.90	76679	5673	0	0	1617
10/23/01	723.92	723.93	82916	0	0	0	0
10/24/01	723.92	723.94	85486	0	0	2022	0
10/25/01	723.92	724.01	100784	0	0	0	0
10/26/01	723.92	724.15	130060	0	0	0	0
10/27/01	723.92	724.24	150429	0	0	0	1617
10/28/01	723.92	724.28	160238	0	0	0	809
10/29/01	723.92	724.27	159066	0	0	0	809
10/30/01	723.92	724.29	161569	0	0	0	2426
10/31/01	723.92	724.28	160699	0	0	0	1617
11/01/01	723.85	724.25	153257	0	0	0	12938
11/02/01	723.48	724.23	149640	0	0	0	0
11/03/01	723.44	724.23	149609	0	0	81535	809
11/04/01	723.60	724.17	135726	0	0	5391	0
11/05/01	723.83	724.03	105093	0	0	0	0
11/06/01	723.82	724.04	107272	0	0	0	0
11/07/01	723.82	724.05	108051	0	0	0	1617
11/08/01	723.46	724.05	107917	0	0	0	0
11/09/01	723.83	724.04	107282	0	0	0	1617
11/10/01	723.83	724.04	106145	0	0	0	2426
11/11/01	723.83	724.03	104509	0	0	0	0
11/12/01	723.83	724.00	97667	0	0	0	0
11/13/01	723.83	723.94	85232	0	0	0	0
11/14/01	723.83	723.91	77118	0	0	0	0
11/15/01	723.83	723.93	81821	0	0	0	14555
11/16/01	723.83	723.94	85511	0	0	0	1617
11/17/01	723.83	723.94	84532	0	0	0	4043
11/18/01	723.82	723.94	83876	0	0	0	0
11/19/01	723.81	723.92	80454	0	0	0	3234
11/20/01	723.80	723.92	79343	0	0	674	0
11/21/01	723.78	723.91	78000	0	0	2695	0
11/22/01	723.77	723.91	77733	0	0	0	0

Date	River Level (ft)	Bill. level (ft)	Volume (ft3)	Inflow (ft3)	Outflow (ft3)	Precipitation(ft3)	ET (ft3)
11/23/01	723.75	723.90	76332	0	0	0	1617
11/24/01	723.74	723.90	75828	0	0	0	7278
11/25/01	723.72	723.90	75828	0	0	2022	0
11/26/01	723.71	723.90	75828	0	0	4043	0
11/27/01	723.70	723.90	75658	0	0	27628	0
11/28/01	723.68	723.90	75318	0	0	0	0
11/29/01	723.67	723.90	74807	0	0	0	3234
11/30/01	726.01	723.89	74127	366392	0	0	809
12/01/01	723.64	723.89	73475	0	0	0	3234
12/02/01	725.21	724.04	106478	226914	0	0	0
12/03/01	725.67	724.04	106478	312636	0	0	0
12/04/01	725.68	724.42	191507	314044	49180	0	0
12/05/01	724.05	725.19	378794	0	0	0	0
12/06/01	724.00	725.23	388556	0	0	18194	0
12/07/01	724.06	725.10	356491	0	0	0	0
12/08/01	724.03	724.96	320970	0	0	0	0
12/09/01	723.96	724.88	300945	0	0	674	0
12/10/01	723.88	724.80	281100	0	0	0	1617
12/11/01	723.81	724.72	261954	0	0	42452	0
12/12/01	723.69	724.65	246910	0	0	0	0
12/13/01	723.55	724.62	239784	0	0	16172	0
12/14/01	723.66	724.59	232442	0	0	10781	0
12/15/01	723.81	724.57	226744	0	0	74797	0
12/16/01	724.40	724.60	233317	0	0	674	0
12/17/01	725.08	724.63	241814	169559	132495	0	0
12/18/01	725.75	724.65	246894	324166	142047	0	0
12/19/01	726.27	724.96	320841	394217	298254	0	0
12/20/01	727.00	725.96	580303	350676	998612	0	0
12/21/01	726.83	726.02	596016	310220	1045789	5391	0
12/22/01	725.79	726.01	593038	0	0	0	0
12/23/01	725.05	725.71	511217	0	0	0	6469
12/24/01	724.57	725.28	400257	0	0	0	2426
12/25/01	724.15	724.91	308566	0	0	0	1617
12/26/01	724.09	724.98	325201	0	0	0	2426
12/27/01	724.10	725.13	364149	0	0	0	0
12/28/01	724.10	725.29	403757	0	0	0	0
12/29/01	724.11	725.45	443194	0	0	0	0
12/30/01	724.02	725.46	447485	0	0	6065	1617
12/31/01	724.00	725.41	432970	0	0	0	1617